



Procedures and Guidelines

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Responsible Office: 572/Flight Dynamics Analysis

Title: Analytical Design of Spacecraft Missions (Procedure Guide)

1 PURPOSE

This procedure establishes guidelines for the technical efforts related to mission design in the areas of orbit and attitude design, determination, and control for spaceflight missions supported by the Guidance, Navigation, and Control Center (GNCC).

Employees will use this process in support of the production and review of GNCC output.

2 REFERENCES

The NASA Mission Design Process, Dr. Michael G. Ryschkewitsch, Goddard Space Flight Center, December 22, 1992

Spacecraft Attitude Determination and Control, Edited by James R. Wertz, Reidel Publishing, Reprinted 1986, ISBN 90-277-1204-2 (paperback.)

Space Mission Analysis and Design (Second Edition), Edited by Larson, Wiley J. and Wertz, James R., Microcosm, 1992, ISBN 1-881883-01-9 (paperback)

3 SCOPE

These guidelines apply to anyone providing analytical support to projects supported by the GNCC and covered by the scope of the GSFC Quality Management System.

Application of these guidelines is limited to prelaunch analyses for missions under development or proposed. They do not apply to postlaunch activities or to prelaunch simulations in preparation for mission operations. Involvement of analysis personnel in those activities would be covered under a procedure written for operations support.

4 DEFINITIONS

(None)

5 AUTHORITIES & RESPONSIBILITIES

5.1 All GNCC employees will follow this procedure in all efforts covered by it.

5.2 Implementation guidelines may be modified or waived due to extenuating circumstances, such as limitation of time and/or resources, or customer request. These procedures may be waived in order to use existing contractor ISO 9000 procedures. Changes and waivers must be documented by the analysis team and approved by the customer and the Chief of the GNCC or his designee.

5.3 The head of the Flight Dynamics Analysis Branch (FDAB) will be responsible for assigning analysis team members, approving budgets, and arranging funding. At the discretion of the branch head, considering the scope of the analysis effort and the number of analysts involved, a lead analyst may be identified to serve as the external point of contact and/or to coordinate activities of the analysis team.

5.4 The FDAB head will identify the team's customer. Typically, the customer is the flight project systems engineer, a study manager, or a principal investigator. Others within and without the GNCC will interact freely with members of the analytical team. However, only the team's customer has immediate authority regarding priorities and technical requirements that affect the team.

5.5 FDAB management has the authority, in consultation with the customer, for approving and modifying any programmatic relating to the analytical effort.

6 IMPLEMENTATION

6.1 Define the Mission Requirements

The analysis team generates a statement of the mission requirements (or accepts one from the customer) and obtains the concurrence of the customer, and any other GNCC personnel who have been assigned. It is the customer's responsibility to obtain the concurrence of all interested parties who are not part of the GNCC organization.

6.2 Initial Planning

6.2.1 The GNCC management verifies that the analytical team is composed of individuals with the required technical skills. Newly assigned personnel will review the requirements, which will be modified if those individuals become aware of deficiencies.

6.2.2 Team members review the mission requirements to assess the usefulness of existing analytical tools for supporting the analyses.

6.2.3 The analysis team submits a budget, if required, that includes personnel costs, travel, training, the procurement of analytical tools that are needed but not available, and any other items considered necessary.

6.2.4 Analytical tools not already available will be procured or developed.

6.2.5 The analysis team develops a schedule of deliverables, specifies the information to be conveyed, and obtains the concurrence of the customer. The deliverables must be in a form sufficient to document that delivery has occurred, what was delivered, and what is required to reproduce the results. A verbal reporting of results is not sufficient.

Deliverables typically address matters related to items in the following list. For an individual design effort, perhaps only one, two, or a few are appropriate. For others, many may be needed.

- definition of coordinate systems and other conventions associated with the analyses
- recommended nominal spacecraft trajectory, effects of non-nominal launch
- launch vehicle options
- launch window
- orbit decay predictions
- shadow predictions
- potential for observing remote targets or make in-situ measurements
- radiation dosage predictions
- attitude profiles
- recommendations about attitude sensors and actuators
- orbit control profiles
- fuel budgets for orbit and attitude control, recommendations about the propulsion system
- power budget profiles
- recommendations about the power system
- contact characteristics for ground stations, TDRS, GPS, other satellites and constellations
- orbit determination accuracy
- recommendations regarding the navigation system (GPS matters, for example)
- recommendations regarding onboard data systems
- recommendations regarding software that operations personnel may need but not anticipate
- specification of algorithms for operations (ex: for mission planning, science scheduling)
- guidance, navigation, and control mode definitions, including safhold mode
- control mode error budgets
- control mode rigid body stability margins
- structural mode reduction analysis
- control mode flexible body stability analysis
- high fidelity models of the selected sensor and actuator hardware
- high fidelity non-linear time domain simulation (HiFi)
- control mode performance analysis using HiFi simulation
- algorithm document which details the control law equations and logic that would be needed by the flight software team for software coding
- an assessment of how well the mission, as designed, will meet the requirements
- other matters of interest that may have surfaced during the course of the effort.

6.3 Procurement

As required, including the software noted in section 6.2.4.

6.4 Detailed Design

6.4.1 The analysis team will identify whatever personnel and organizational interfaces are necessary and will ensure that all parties who must interact agree on what information is to be exchanged. Some interfaces may be with individuals not part of the analytical team. For example, the customer is not part

of the analytical team, nor, perhaps, are those developing flight hardware. However, both are important for the larger effort of which the analytical team is a part.

6.4.2 Analysts in the various disciplines will apply the stated requirements to produce a design or analysis that meets those requirements.

6.4.3 The analysis team will keep abreast of developments that could alter the stated requirements. This will be done by representation at project and working group meetings,

Interactions among analytical team members and those of other teams (for example, power system designers) will occur freely and informally. These could lead to changes in the stated requirements also.

6.5 Reviews

6.5.1 The analysis team will participate in one or more peer reviews of the design. Peer reviews will have been included in the schedule.

6.5.2 The analysis team will participate in formal and informal reviews as specified by the customer.

6.6 Changes in Requirements

Whenever a stated requirement changes or a new one is added, the analysis team will execute the first step of the procedure and coordinate whatever parts of subsequent steps are required.

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	10/29/1998	Initial Release